COMBAT ABLS:
BURN CARE AFTER THE FIRST 24 HOURS

U.S. Army Institute of Surgical Research

Fort Sam Houston, Texas

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COMBAT ABLS

OBJECTIVES

At the conclusion of this module, the student will understand:

- The physiology of burn injury after the first 24 hours
- The care of the burn patient between hours 24 and 72 post-injury
- The continued need to transfer burn patients to definitive care as soon as possible

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INTRODUCTION

- The ABLS Course teaches care of the burn patient in the first 24 hours. The ultimate goal is to have the burn patient transferred to burn center care within this timeframe

- Timely transfer may not be possible in a military or wartime setting

- This module covers burn care in hours 24 to 72 for situations where timely transfer is not possible

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PHASES IN BURN CARE

- Emergency assessment and care (ABCs)
- Resuscitation (hours 0-48)
- Definitive care (day 3 until wounds are closed)
- Rehabilitation and reintegration (begins during resuscitation and lasts entire lifespan)

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THE SECOND 24 HOURS POSTBURN

- Edema formation increases
- A well-resuscitated patient goes from the ‘Ebb’ to the ‘Flow’ phase of circulation
- The patient becomes hypermetabolic
- Capillary integrity is restored
- Respiratory failure from smoke inhalation may worsen

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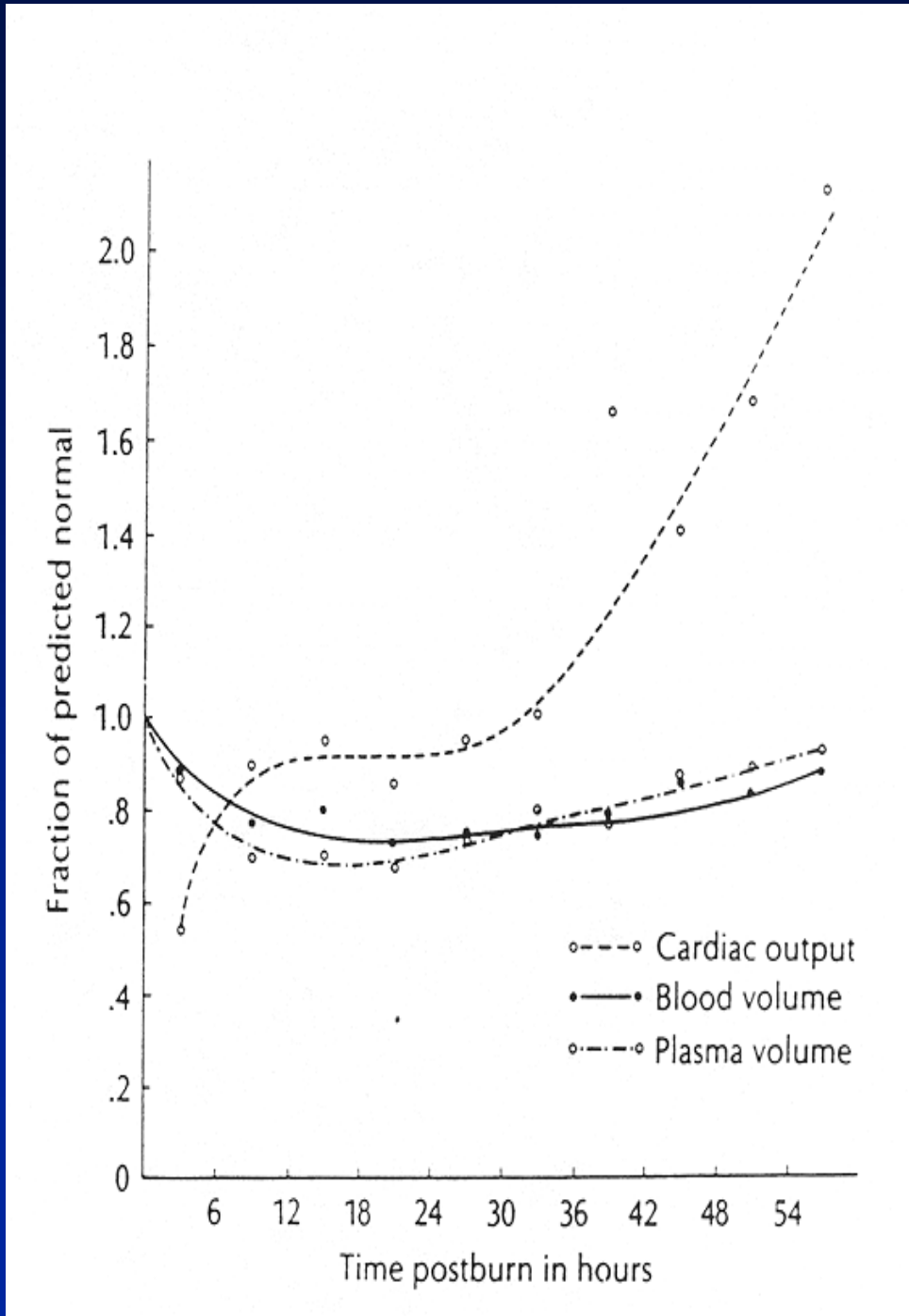
Ebb and Flow

- During the first 24 hours, cardiac output is decreased
- With proper resuscitation, cardiac output normalizes at 24 hours
- At 36 hours, the patient becomes hypermetabolic with cardiac output 2-2.5 x normal



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MANAGEMENT

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MANAGEMENT

- EKG monitor
- Pulse oximeter
- End-tidal CO_2 monitor
- Daily CXR and CBC
- BID measurement of electrolytes, Mg, Ca, PO_4

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MANAGEMENT

- Airway
- Breathing
- Circulation
- Burn wound
- GI system
- Extremities
- Infection

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AIRWAY

- The need for intubation will likely have been recognized in first 24 hrs
- If not already intubated, frequently re-assess patency of airway
- If intubated, suction tube frequently to maintain patency
- Monitor with pulse oximeter and end-tidal CO_2 monitor if available

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AIRWAY

- Airway and facial edema is maximal at 48 hours
- Protect the ET Tube !
- Elevate head to reduce edema
- Extubation attempts should be deferred until edema has resolved
- Continued intubation facilitates transfer: contact burn center before attempting extubation

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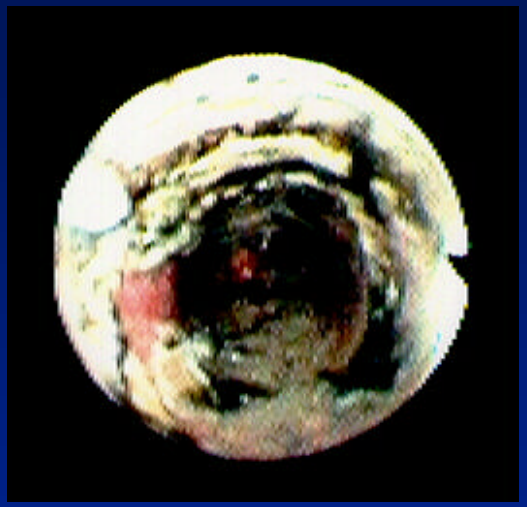
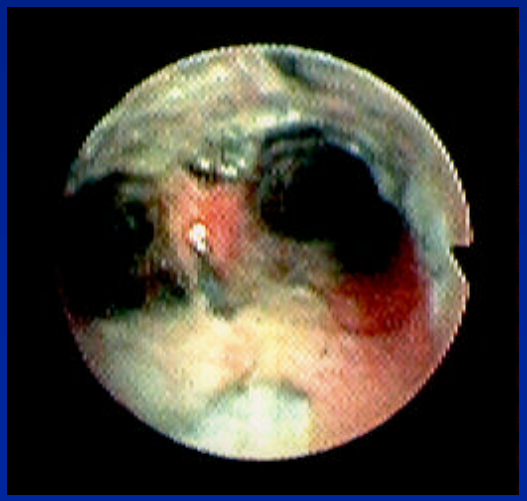
AIRWAY

- Fiberoptic bronchoscopy may need to be repeated frequently for pulmonary toilet
- Patients with documented smoke inhalation injury should receive aerosolized heparin, 5000-10,000 units q 4 hours
- If initial bronchoscopy was negative but clinical suspicion of inhalation injury is high, repeat bronchoscopy in second 24 hrs
- Under-resuscitated patients may not show airway erythema or edema initially, but will show positive bronchoscopic signs after successful resuscitation





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BREATHING

- Continue to assess adequacy of breathing and ventilation
- As edema develops, re-assess for need for chest escharotomy
- Daily chest radiograph

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BREATHING

- Patients with inhalation injury are at high risk of bronchopneumonia
- Bronchopneumonia increases mortality by 40% when superimposed on inhalation injury
- Prophylactic antibiotics are not indicated
- Steroids increase mortality and are contraindicated
- Frequent assessment for signs and symptoms of pneumonia or tracheobronchitis

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DIAGNOSTIC CRITERIA FOR PULMONARY INFECTION

Pneumonia	1) Clinical findings consistent with pneumonia, i.e. pleuritic chest pain, fever, purulent sputum or other signs of sepsis 2) More than 25 polymorphonuclear leukocytes on methylene blue stain of endotracheal secretions with less than 25 squamous epithelial cells per 100x field 3) Roentographic findings consistent with pneumonia 4) Positive sputum cultures (confirmatory but not essential for diagnosis)
Tracheobronchitis	As above without radiographic evidence of infiltrate

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BREATHING

- At first sign of infection, start intravenous antibiotics
- Use sputum Gram Stain, followed by culture to determine organism
- Pneumonia in the first 3-5 days is usually ***Staphylococcus*** sp
- Initial antibiotic of choice is vancomycin
- If Gram Stain indicates Gram negative organisms, use two-drug coverage
- Initial choice is an aminoglycoside and a semisynthetic penicillin

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Respiratory care

- Gentle ventilation
  - Keep PIP < 40 cmH_2O, FiO_2 < 60%
  - Accept pH > 7.2, SaO_2 > 90%, any PCO_2
- Pulmonary toilet
- Bronchodilators as needed
- High-frequency percussive ventilation (VDR)

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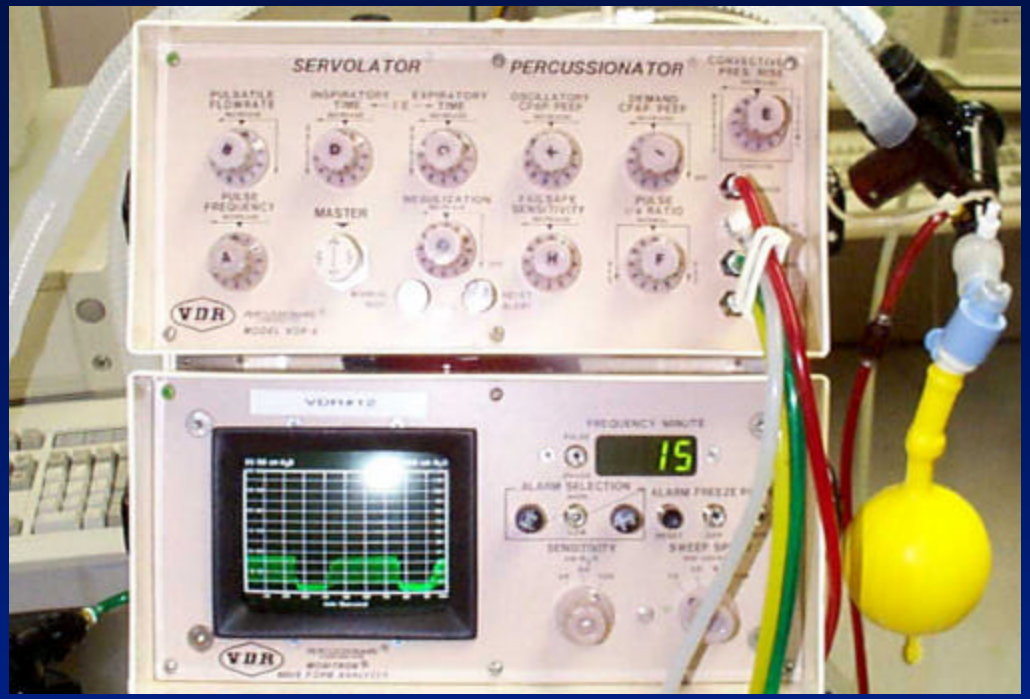
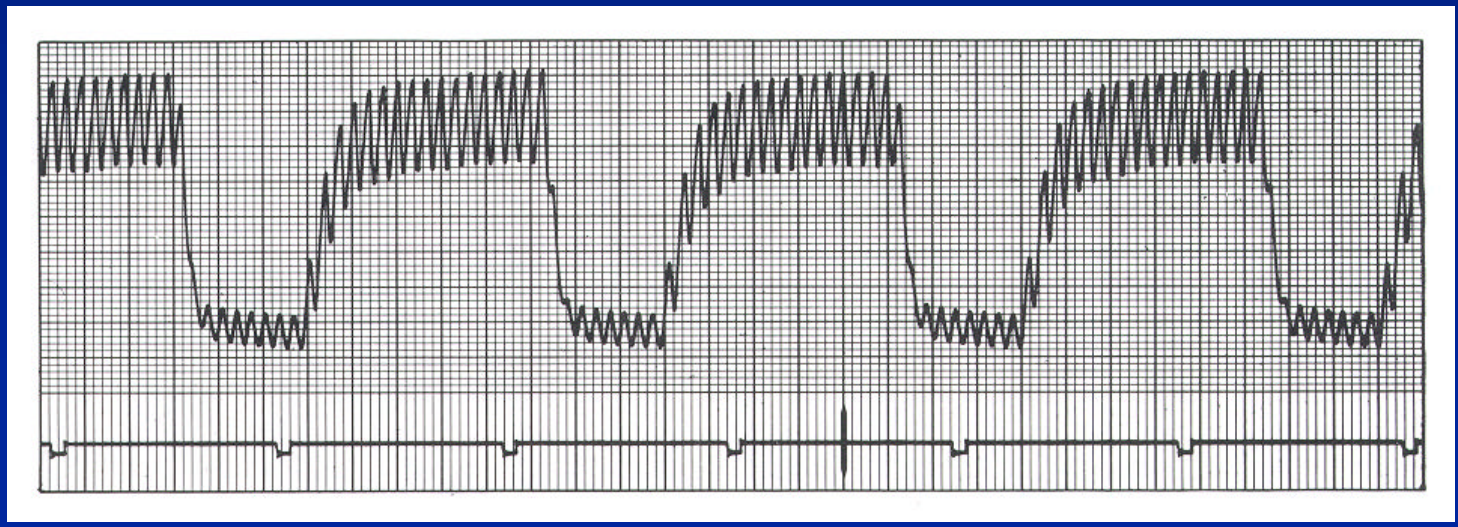
VDR-4

- Volumetric Diffusive Respiration





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CIRCULATION

- Continue to assess peripheral pulses for 48 hours post injury, longer if clinically indicated
- The need for escharotomy after 48 hours is unusual*
- Elevate burned extremities
- Evaluate adequacy of resuscitation
- Change fluids at 24 hours and at 48 hours

*However, missed eschar syndrome may cause limb necrosis and intramuscular infection

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RESUSCITATION

- Capillary permeability returns to normal at 24 hours

- Colloid given after this point generates intravascular oncotic pressure to return interstitial fluid to the vascular tree

Modified Brooke formula:
second 24 h

- Wean off LR based on U.O.
- Colloid: 5% albumin in NS over 24 h
  - 30-49% burn: 0.3 ml/kg/% burn
  - 50-69% burn: 0.4 ml/kg/% burn
  - 70-100% burn: 0.5 ml/kg/% burn
- D5W or D5 ½ NS to replace insensible losses (practice varies)
- Children: maintenance D5LR* continues

*D5LR is the ABLS recommended maintenance fluid for children

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CONTINUE TO ADJUST FLUID RATE BASED ON URINE OUTPUT

Modified Brooke formula:
after 48 h

- Stop albumin
- Continue fluids for maintenance and insensible losses
- Watch serum sodium
  - Evaporative losses → hypernatremia
  - Water overload → hyponatremia
- Replace potassium, phosphate, magnesium, calcium

Modified Brooke formula:
after 48 h

- Maximal weight gain from edema will occur at 48 hours
- Plan fluid administration for next 8 days to return to baseline weight at postburn day 10
- Monitor weight and serum sodium
- Burned skin has a high insensible water loss

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Insensible water losses

- Water losses (ml/hour) =

  (25 + % burn)(body surface area, m^2)

- Water losses (ml/day) =

  (1 ml/kg/% burn)

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Do not over-resuscitate

- Eschar syndrome
- Extremity compartment syndrome
- Abdominal compartment syndrome, GI dysfunction
- Cerebral edema
- Hypoperfusion of zone of stasis and progression of wound depth
- Pulmonary edema
- Airway edema, obstruction

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HYPONATREMIA

- Is almost always due to water excess rather than sodium deficit
- Is usually treated with water restriction
- To avoid hyponatremia, children should never receive IV fluids less hypertonic than D5 ½ NS

Difficult resuscitation

- Patient does not respond in the usual way to fluid resuscitation
  - Requires more than 6 ml/kg/TBSA/1st 24 h
  - Develops worsening metabolic acidosis (base deficit less than -10)
  - Has repeated episodes of hypotension
  - Develops end-organ damage: e.g. dead gut, limb ischemia, ARDS…

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Troubleshooting resuscitation

- Thoracic eschar syndrome
- Missed mechanical trauma
- Presence of diuretics
- Pneumothorax due to line placement
- Cyanide poisoning (rare)
- Abdominal compartment syndrome
- Mesenteric ischemia

Forced diuresis

- Causes
  - Alcohol ingestion
  - Glycosuria (stress response)
  - Diuretic use
- Impact
  - Urine output is driven till profound hypovolemia occurs
- Solution
  - Detect (alcohol level, dipstick urine Q2H)
  - Treat (I.V. continuous insulin)
  - Use PA catheter to assess volume needs

Abdominal compartment syndrome

- Large fluid resuscitations
- Increased intraabdominal pressure
- Decreased preload, CO
- Renal failure
- Mesenteric ischemia
- Decreased lung compliance, increased $ETCO_2$, pCO_2
- Measure bladder pressure

Bedside emergency laparotomy for abdominal compartment syndrome


Non-occlusive
mesenteric ischemia

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Associated injuries

- Determine mechanism of injury
- Do an ATLS workup: look for nonthermal trauma!
- Blast, explosion, MVA, fall, electrocution

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Major trauma

- Treat per ATLS guidelines, etc.
- Diagnostic peritoneal lavage through burned skin: no problem
- Continue burn resuscitation intraoperatively
  - *Do not overresuscitate*
- Anesthetic of choice: ketamine

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BURN WOUND CARE

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BURN WOUND CARE

- ABLS recommends that no topical agent be applied prior to burn center care
- If transfer is delayed, topical therapy will be needed
- Debride wounds immediately and BID
- Apply topical agents

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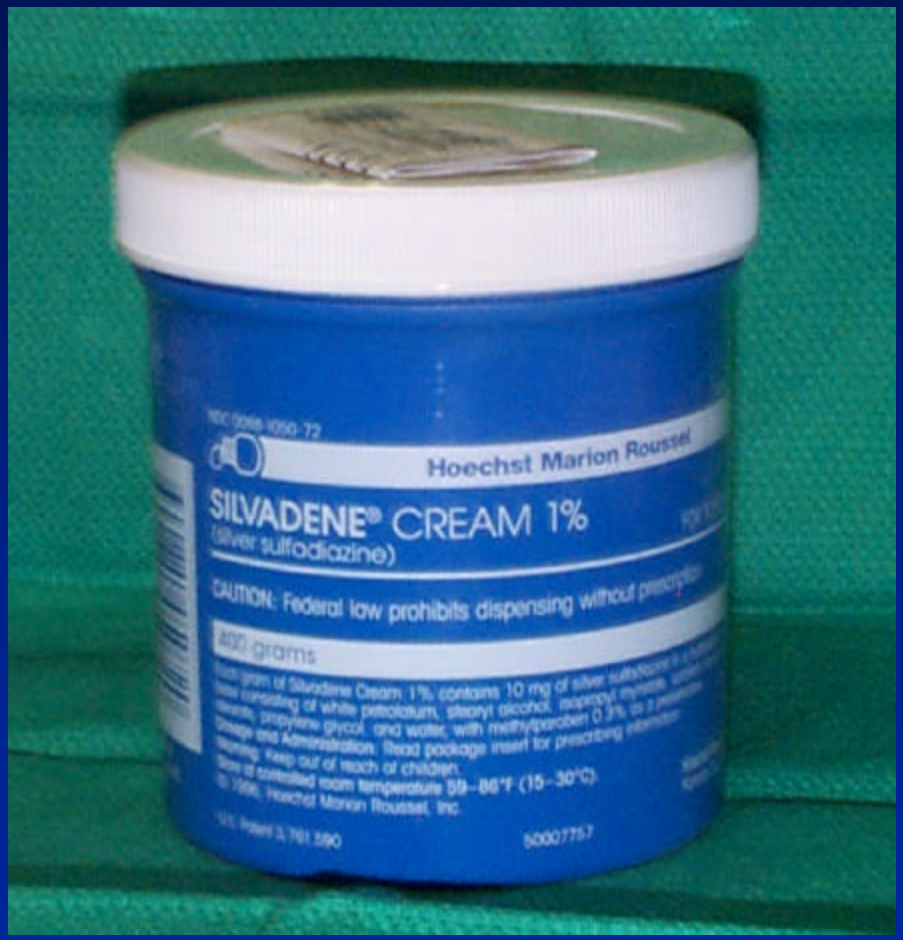
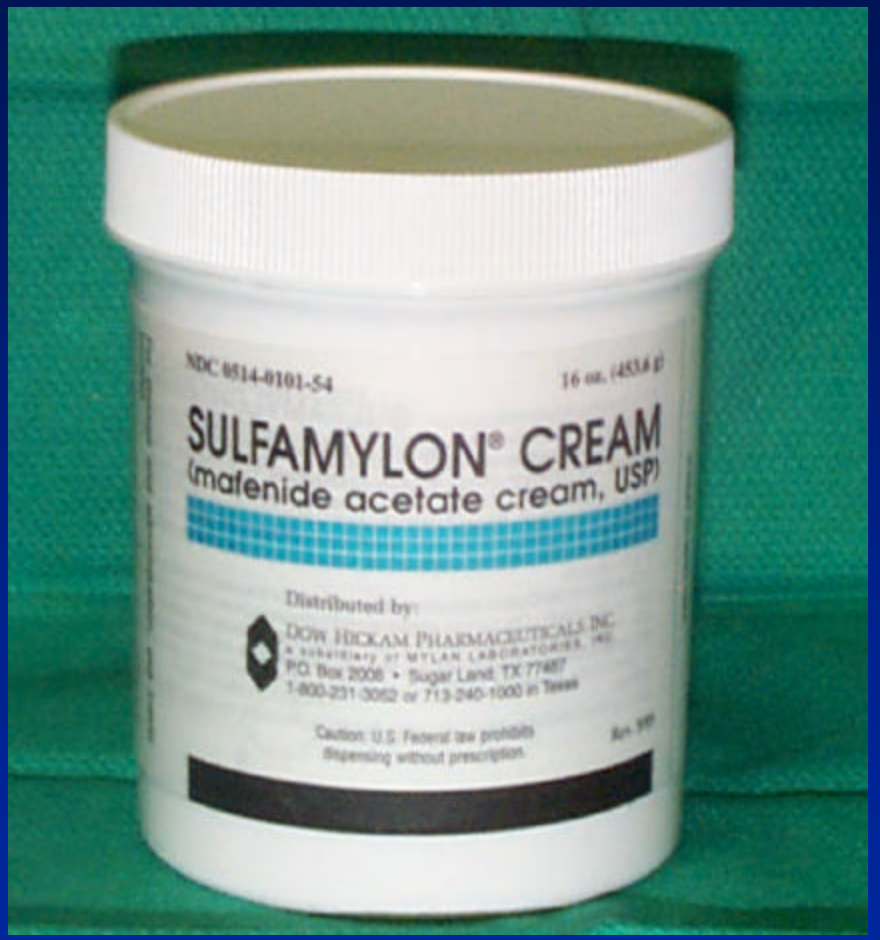
Burn creams



Silver sulfadiazine



Mafenide acetate (Sulfamylon)

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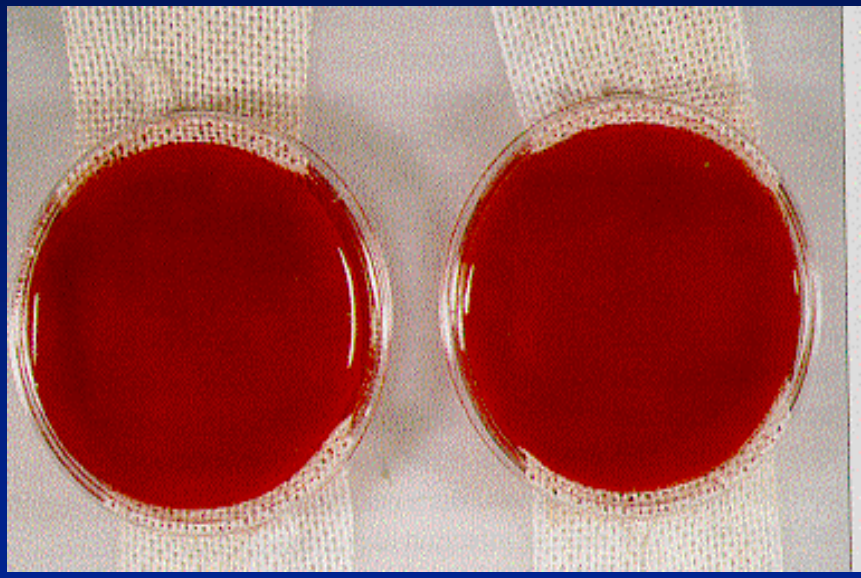
BURN WOUND CARE

- BID wash with aqueous solution of chlorhexidine gluconate
- Iodine-solutions are less effective and some burn flora are resistant
- Apply topical agent 0.5 inch thick
- Surveillance cultures 3x/ week



Culture plates are more effective than swabs for microbial surveillance

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BURN WOUND CARE

- Debridement and dressing changes are painful and require analgesia
- Use small and frequent doses of IV morphine for pain control (2-5 mg every 5-10 minutes)
- Add short acting benzodiazepene (midazolam 1-2 mg every 5-10 minutes) as needed for sedation
- Also effective: ketamine 1 mg/kg
- Monitor as conscious sedation procedure: vital signs / EKG /pulse oximetry

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BURN WOUND CARE

- The best monitoring method for conscious sedation is constant conversation with the patient
- Titrate medication down near end of procedure to avoid over-sedation or hypotension when stimulation is no longer present
- Monitor post-procedure per conscious sedation SOP
- Resuscitative equipment, including airway devices and reversal agents should be immediately available

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TOPICAL AGENTS

- Bacitracin ophthalmic to face
- Mafenide acetate cream BID to ears
- Superficial burns: silver sulfadiazene BID
- Deep burns: alternate use of mafenide acetate (daytime) with silver sulfadiazene (nighttime) to maximize penetration and minimize bacterial resistance

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MAFENIDE ON THE EARS

- Chondritis is a serious infection that may develop in burned ears
- The infection requires radical debridement resulting in significant deformity
- Incidence of chondritis is significantly lower when mafenide cream is used to cover burned ears

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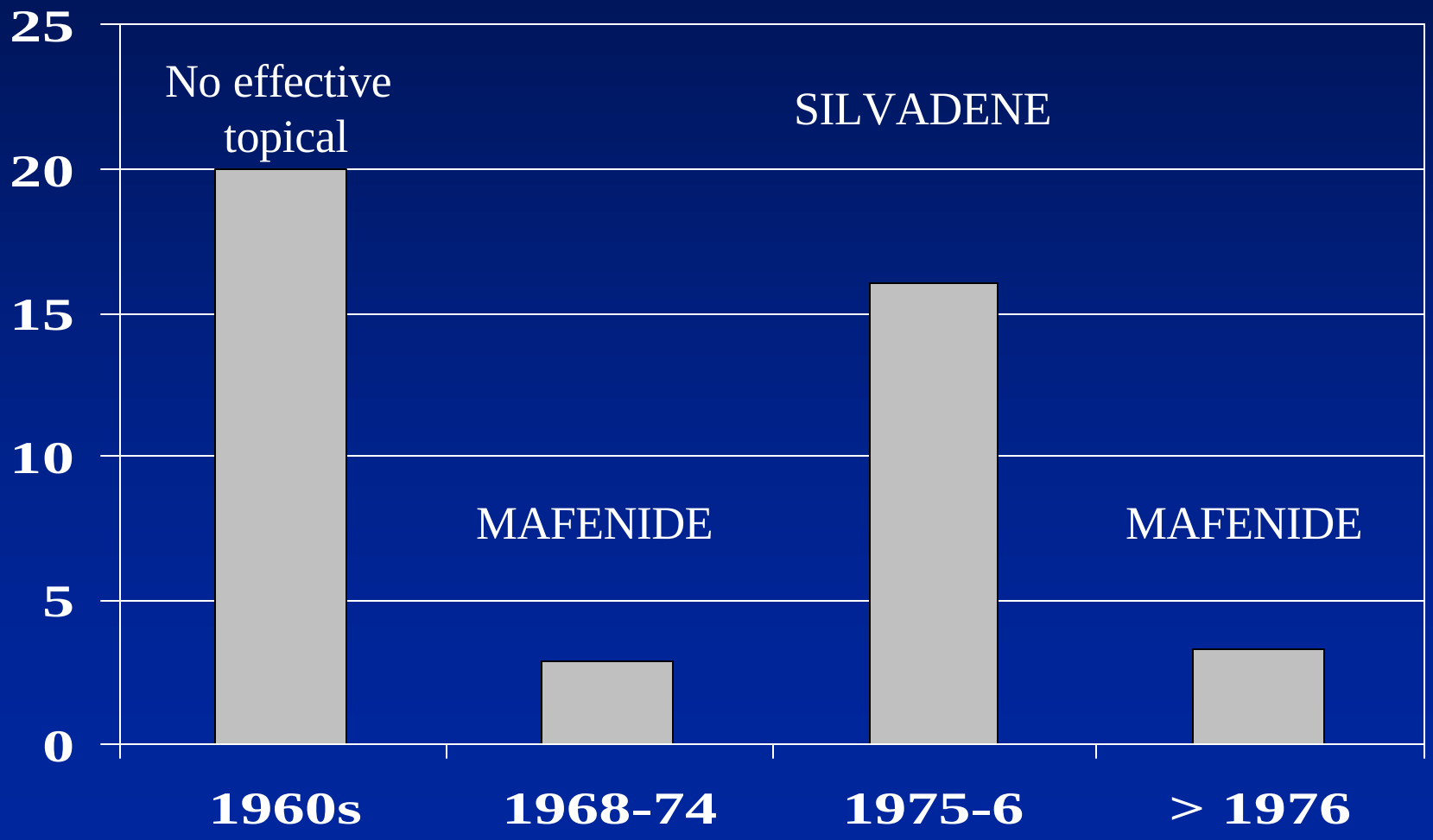
CHONDRITIS OF BURNED EAR

RESULTING DEFORMITY

Chondritis: incidence



Burn wound infection:
two main types

- Burn wound cellulitis
- Invasive Gram-negative burn wound infection
- Invasive Gram-negative infection is rare in contemporary burn practice and unlikely in first 72 hours

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BURN-WOUND CELLULITIS

- More than 2 cm of erythema around wound edges
- Usually presents with fever
- Cause: Streptococcus, Staphylococcus
- Treatment: PO penicillin, if unsuccessful, consider IV penicillin or IV vancomycin

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BURN-WOUND CELLULITIS

- Children may be chronic carriers of Streptococcus and may be at increased risk of cellulitis

- Although prophylactic antibiotics are not indicated in burn care, coverage of pediatric burn patients with PO penicillin is appropriate until results of throat cultures are known

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FEVER

- Fever is a component of the normal hypermetabolic response and should be expected after the first 24 hours
- Leukocytosis in the 14,000 – 18,000 range is a normal response to burn injury
- Because of the hypermetabolic response, cardiac output 2-2.5X normal in association with low systemic vascular resistance may be seen
- The above responses may represent infection or may represent normal physiology
- Frequent contact with the receiving burn center is essential when infection is suspected

FEVER

- In addition to the usual workup,
  - Examine all burn surfaces for signs of cellulitis
  - In burned children, also examine ears for otitis

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Gastrointestinal care

- NG tube for TBSA > 20%
- Stress ulcer prophylaxis
  - H_2 blockers (eg ranitidine)
  - Antacids (alternate Al and Mg)
  - Proton-pump inhibitors (eg omeprazole)
- Enteral feeding
  - Place a Dobhoff tube past the pylorus and start feedings with Osmolyte HN at about 48 h postburn
- Calculate caloric needs
  - Burn size determines metabolic rate

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Extremity burns

- Elevate (pillows)
- Exercise burned hands q hour
- Examine pulses at least q hour
  - Doppler US
  - Radial, ulnar, palmar arch in hand
  - Posterior tibialis, dorsalis pedis
- Loss of pulses: hypotension, eschar, vascular injury, compartment syndrome

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Examine, Exercise, Elevate

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Early and *ongoing* communication with the Burn Center

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SUMMARY

- Whenever possible, burn patients should be transferred to definitive care within the first 24 hours
- Military contingencies may preclude early transfer, and military health care providers must be familiar with the longer-term management of burn patients
- Capillary integrity is restored at 24 hours post injury, and resuscitation fluids are changed from crystalloid to colloid and free water
- Colloid is discontinued at 48 hours post-injury

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SUMMARY

- Debridement of burns and placement of topical antimicrobial agents is required when transfer is delayed beyond 24 hours
- Debridement and wound care require conscious sedation medications and monitoring procedures
- Burned extremities should be elevated and ranged
- Burn wound cellulitis may occur and responds to antibiotics

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SUMMARY

- Pneumonia may complicate smoke inhalation injury in the first days following injury. The presence of pneumonia significantly worsens outcome
- Diagnosis of pneumonia requires a high index of suspicion
- Burn patients exhibit a hyper-metabolic response at 24-36 hours post injury.
- Fever, leukocytosis, increased cardiac output and decreased systemic vascular resistance may be a normal hypermetabolic response or may represent infection
- Frequent communication with the receiving burn facility is essential

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Army Burn Team: 210-222-BURN

TOPICAL ANTIMICROBIAL THERAPY OF THE BURN WOUND

Agent	Advantages	Disadvantages
Mafenide acetate 11.1% cream	Best eschar penetration, most widely studied agent; broad spectrum, bacteriostatic against Gram-positive and Gram-negative, especially effective against *Pseudomonas aeruginosa* and *Clostridia* spp.; no Gram-negative resistance	Painful to apply on partial thickness burns; metabolic acidosis from carbonic anhydrase inhibition; accentuates hyperventilation; minimal coverage of yeasts; poor coverage of *Providencia* spp.; most effective when utilized with open dressing technique
Mafenide acetate 5% aqueous solution	Good eschar penetration; useful in wet dressings to facilitate debridement; especially effective on wound bed after eschar removal; effective dressing for open granulating wounds or over meshed autografts	Requires wet dressings; may contribute to hypothermia; not Food and Drug Administration approved in USA
Silver sulfadiazine 1% cream	Painless on application; good Gram-negative and yeast coverage; infrequent hypersensitivity; may be used with open or closed dressings; may be combined with nystatin to increase yeast coverage	Poor eschar penetration; transient leukopenia; poor or no coverage of *Enterobacter*, *Klebsiella*, *Clostridia* and some *Pseudomonas* spp.; Plasmid-mediated resistance to this agent may extend to other antimicrobials
Silver nitrate 0.5% solution	Bacteriostatic against a broad spectrum of Gram-positive, Gram-negative and yeast-like organisms; effective for patients with toxic epidermal necrosis syndrome or burn patients allergic to sulfa drugs	Little to no eschar penetration; precipitates on tissue contact; works best on minimally colonized or debrided tissue; stains tissue, clothing and bedlinens; causes hyponatremia, hypokalemia and hypocalcemia; wet dressings may contribute to hypothermia; poor coverage of *Klebsiella* and *Providencia* spp.
Sodium hypochlorite 0.025% solution	Bactericidal against a broad spectrum of Gram-positive and Gram-negative organisms; inexpensive	Must be freshly compounded; requires wet dressings, which may contribute to hypothermia
Gentamicin sulfate 0.1% cream	Broad spectrum	Rapid emergence of resistant organisms; no longer in common use
Nitrofurazone 0.2% cream	Effective against *Staphylococcus* spp. [including methillin-resistant *Staphylococcus aureus* (MRSA)] and nonpseudomonad Gram-negative organisms	Poor coverage of *Pseudomonas* spp.
Mupirocin 2% cream	Effective against Gram-positive organisms, including MRSA; effective against some Gram-negative enteric organisms; useful for graft infection secondary to *Staphylococcus* spp.	Expensive; not a first line therapy
Nystatin 100,000 units/g	Effective against *Candida* spp. and most true fungi	No antibacterial coverage
Clotrimazole 1% cream	Broad-spectrum antifungal effective against *Candida*, *Trichophyton* and *Microsporum* spp.; minimal systemic absorption from topical use	No antibacterial coverage; poorly absorbed through normal skin; eschar penetration unknown